GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. E-27-609 — DATE 10/5/81

Project Director: Dr. Wallace Carr — School/Lab Textile Engineering

Sponsor: J.P. Stevens & Co., Inc.; Greenville, S.C.

Type Agreement: Research Project Agreement dated 9/24/81

Award Period: From 9/24/81 To 12/24/81 (Performance) ---- (Reports)

Sponsor Amount: $1,700 — Contracted through:

Cost Sharing: N/A — ~~GTRI~~/GIT

Title: Feasibility of Operating the Machnozzle with Compressed Air

ADMINISTRATIVE DATA

OCA Contact ______

1) Sponsor Technical Contact:

2) Sponsor Admin/Contractual Matters:

M. A. Fernandez, Manager
Energy & Process Engineering
J. P. Stevens & Co., Inc.
Box 2850
Greenville, S. C. 29602

Defense Priority Rating: N/A — Security Classification: N/A

RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with None proposed

COMMENTS:

COPIES TO:

Administrative Coordinator	Research Security Services	EES Public Relations (2)
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Accounting	Legal Services (OCA)	Project File
Procurement/EES Supply Services	Library	Other ______

FORM OCA 4:781

GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date 6/15/82

Project Title: Feasibility of Operating the Machnozzle with Compressed Air

Project No: E-27-609

Project Director: Dr. Wallace Carr

Sponsor: J. P. Stevens & Co., Inc.; Greenville, S. C.

Effective Termination Date: 12/24/81

Clearance of Accounting Charges: 12/24/81

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice ~~and Closing Documents~~
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other ____________

Assigned to: Textile Engineering (School/~~Laboratory~~)

COPIES TO:

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Computer Input
Project File
Other ____________

FORM OCA 10:781

FEASIBILITY OF OPERATING THE MACHNOZZLE

WITH COMPRESSED AIR

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The School of Textile Engineering
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Prepared for

J. P. Stevens Company, Inc.

INTRODUCTION

The test results of the in-plant demonstration of the Machnozzle as a predrying device indicated that the Machnozzle is a viable way of predrying fabrics. The Machnozzle substantially reduced the regain in sheeting-weight fabrics, and its energy requirements compared favorably with those for steam cans.

Although the Machnozzle may be operated with either steam or compressed air, the Machnozzle studies conducted by Georgia Tech researchers have used steam. At the conclusion of the in-plant demonstration, the feasibility of using air instead of steam was considered because of two potential advantages. One was that working with the Machnozzle when air is used should be easier and safer. The other was that calculations indicated that even though approximately 65% of the thermal energy in steam can be recovered, operating the Machnozzle with air may be more economical than with steam. Production of steam requires providing heat to change water from the liquid to the vapor phase. Since water has an extremely high latent heat of vaporization, producing steam requires more energy than compressing air. For example, producing one pound of steam at 125 psig requires approximately 1603 BTU (assuming a boiler efficiency of 72%). Assuming 65% of the thermal energy in the steam is recovered, approximately 560 BTU's are required per pound of steam used by the Machnozzle. Calculations indicated that compressing a pound of air to 125 psig will require approximately 115 BTU. Therefore, operation of the Machnozzle with compressed air appeared to be less energy consumptive.

OBJECTIVE

The objective of the project was to determine the feasibility of operating the Machnozzle with compressed air. The moisture removing ability and the energy efficiency of a Machnozzle operating on compressed air were to be determined.

TEST PLAN

Tests were conducted to determine the feasibility of operating the Machnozzle with compressed air. Data were taken to establish the perfromance and drying efficiency of the Machnozzle in removing moisture from sheeting-weight fabrics. The primary parameters varied during the tests were fabric type, process speed, and air pressure. The two responses monitored were air flow rate and fabric moisture level. The tests conducted are summarized in Table 1.

OPERATION OF MACHNOZZLE WITH AIR

The pilot-scale test using the 16-inch Machnozzle were run with a Machnozzle slit width of approximately 0.001 inch. The initial plans were to conduct the air test with the slit set at the same width (0.001 inch); however, the initial test with air revealed that very little air flowed through the nozzle at this setting of the slit. Steam was flowed through the Machnozzle to determine if changes in the system had occurred since the pilot-scale test. Results similar to those obtained during the pilot-scale study were obtained. Thus, it was concluded that the operations of the Machnozzle with air at room temperature would require a wider slit.

Table 1. Summary of Tests

Fabric Type	Process Speed (YPM)	Test Condition
Muslin 65/35 Polyester/Cotton	50	Machnozzle Pressure (psig) Steam: 95* Air: 40, 60, 80, 100
	75	Machnozzle Pressures (psig) Steam: 95 Air: 20, 40, 60, 80, 100, 120
	100	Machnozzle Pressures (psig) Steam: 95 Air: 60, 80, 100, 120
Percale 50/50 Polyester/Cotton	75	Machnozzle Pressures (psig) Steam: 95 Air: 20, 40, 60, 80, 100, 120
Textured 80/20 Polyester/Cotton	75	Machnozzle Pressures (psig) Steam: 95 Air: 20, 40, 60, 80, 100, 120

* Maximum obtainable steam pressure was approximately 95 psig.

A 0.003-inch shim was fabricated and installed in the Machnozzle . The initial test with the 0.003-inch shim indicated that the air flow rate was sufficiently high to obtain water removal from the fabric. Since time and budgetary limitations of the project did not allow optimization of the slit width, all of the air tests were conducted using the 0.003-inch shim. If satisfactory results can be obtained using a smaller shim, obviously the energy requirements of the Machnozzle can be reduced.

RESULTS

The results of the tests are summarized in Tables 2 and 3. The performance of the Machnozzle using compressed air was similar to its performance in the pilot-scale study where steam was used. As supply pressure was increased for 0 psig to 80 psig, the moisture-removal ability of the Machnozzle improved steadily. Increasing air pressure above 80 psig had marginal effect on moisture removal. Optimal operational pressure appears to be between 80 and 100 psig. At these pressures, fabric regain was reduced from approximately 80% to 35% (average for the three fabrics). The residual regain when steam was used at a pressure of 95 psig was approximately 28% (average for the three fabrics).

The gas consumption (in pounds of gas per pound of water removed) was higher for air than steam as can be seen in Table 2. The ratio of required mass of air to mass of steam ranged from 1.36 to 2.26 (see Table 3). Since these numbers are for air tests using a 0.003-inch shim in the Machnozzle and for steam tests using no shim, optimization of slit width would probably lower this ratio.

Although the gas consumption was higher when air was used, the energy consumed in producing the compressed air was lower than that required to produce steam. The ratio of energy required to compress air to remove one pound of water to the energy required to produce steam to remove one pound of water ranged from approximately 0.13 BTU_{air}/BTU_{steam} to 0.22 BTU_{air}/BTU_{steam}. The assumptions used to calculate the ratio of energy requirements are given in Table 2.

The ratio of energy cost to remove water using air to that using steam ranged from 0.40 to 0.65 (see Table 3). The ratio was based on the assumption that 1 BTU of electrical energy costs three times as much as thermal energy.

CONCLUSIONS

The Machnozzle performed well as a predrying device when compressed air was used as the gas medium. Higher mass flow rates were required for air than steam; however, the slit width was increased for the air tests. Optimization of slit width probably would reduce the air requirements. Although higher gas flow rates were used during the air tests, the energy required to produce the compressed air was less than required to produce steam.

An economic analysis should be made to determine the feasibility of utilizing air versus steam as the working medium in the Machnozzle. Such an analysis was beyond the scope of this project; however, the data presented in this report can be used in making an economic analysis.

Table 2. Summary of Test Results

Fabric	Process Speed (YPM)	Gas	Gas Pressure (Psig)	Regain Before Machnozzle (%)	Regain After Machnozzle (%)	Reduction in Regain (%)	Rate of Moisture Removal $\frac{Lb_w}{HR\text{-}Inch}$	Rate of Gas Consumption $\frac{Lb_{gas}}{HR\text{-}Inch}$	Gas Requirement Per Pound of Water Lb_{gas}/Lb_w	Energy Requirements Per Pound of Water Removed (BTU/Lb_w)*
Muslin 65/35 Polyester/ Cotton (3.4oz/yd^2)	50	Air	40	80.3	54.7	25.6	4.53	12.8	2.82	329
		Air	60	83.7	46.4	37.3	6.61	19.1	2.89	332
		Air	80	81.0	32.7	48.3	8.55	23.8	2.78	320
		Air	100	81.9	32.7	49.2	8.71	27.8	3.19	367
		Air	120	78.0	28.2	49.8	8.82	31.8	3.61	415
		Steam	95	79.2	32.1	47.1	8.34	17.0	2.04	2426
	75	Air	20	82.8	68.1	14.7	3.91	7.2	1.84	212
		Air	40	79.7	58.1	21.6	5.75	12.8	2.23	256
		Air	60	80.4	48.6	31.8	8.46	19.1	2.26	260
		Air	80	81.0	39.4	41.6	11.07	23.8	2.15	247
		Air	100	81.1	33.9	47.2	12.56	27.8	2.21	254
		Air	120	77.2	33.1	44.1	11.73	31.8	2.71	312
		Steam	95	82.5	29.0	53.5	14.23	17.0	1.19	1415
		In-Plant Demonstration	100	77.0	19.0	58.0	15.4	13.2	0.86	1019
	100	Air	60	78.9	46.8	32.1	11.36	19.1	1.68	193
		Air	80	78.2	44.7	33.5	11.86	23.8	2.01	231
		Air	100	78.3	34.3	44.0	15.58	27.8	1.78	205
		Air	120	78.0	35.1	42.9	15.19	31.8	2.09	240
		Steam	95	81.5	34.3	47.2	16.71	17.0	1.02	1213
		In-Plant Demonstration	100	77.0	27.0	50.0	17.70	13.2	0.75	886
Percale 50/50 Polyester/ Cotton (3.4oz/yd^2)	75	Air	20	71.6	61.4	10.2	2.71	7.2	2.65	305
			40	72.1	50.2	21.9	5.83	12.8	2.20	253
			60	72.9	45.3	27.6	7.34	19.1	2.60	299
			80	69.0	38.2	30.8	8.19	23.8	2.90	334
			100	72.6	37.3	35.3	9.38	27.8	2.96	340
			120	70.0	39.6	30.4	8.09	31.8	3.93	452
		Steam	95	73.1	24.3	48.8	13.0	17.0	1.31	1558
		In-Plant Demonstration	95	75.0	21.0	54.0	14.3	13.2	0.92	1094
Textured 80/20 Polyester/ Cotton (2.9oz/yd^2)	75	Air	20	85.4	64.3	21.1	4.79	7.2	1.50	173
			40	84.8	47.3	37.5	8.51	12.8	1.50	173
			60	86.6	38.1	48.5	11.01	19.1	1.73	199
			80	85.8	30.4	55.4	12.58	23.8	1.89	217
			100	81.9	27.0	54.9	12.46	27.8	2.23	256
			120	81.5	26.1	55.4	12.58	31.8	2.52	290
		Steam	95	78.0	18.4	59.6	13.53	17.0	1.26	1498
		In-Plant Demonstration	100	85.0	26.0	54.0	12.23	13.2	1.08	1283

*Based on the assumptions:

1. The production of one pound of steam @ 95psig requires 1189 BTU/lbs.
2. Boiler efficiency not included in calculation.
3. Compressor requires 115 BTU/lb.
4. Power plant and distribution efficiency not included.

Table 3. Comparison of Air and Steam When Used as Machnozzle Gas

Fabric Type	Process Speed (ypm)	Gas	Reduction In Regain (%)	Gas Consumption Lb_{gas}/Lb_w	Air-Steam Mass Consumption Ratio Lb_a/Lb_s	Energy Consumption BTU/Lb_w	Air/Steam Energy Consumption Ratio BTU_a/BTU_s	Air/Steam Energy Cost Ratio*
Muslin 65/35 Polyester/Cotton (3.4 oz/yd^2)	50	Air	48.3	2.78	1.36	320	0.132	0.396
		Steam	47.1	2.04		2426		
	75	Air	47.2	2.21	1.85	254	0.180	0.54
			53.5	1.19		1415		
	100	Air	44.0	1.78	1.75	205	0.169	0.507
		Steam	42.9	1.02		1213		
Percale 50/50 Polyester/Cotton (3.4 oz/yd^2)	75	Air	35.3	2.96	2.26	340	0.218	0.654
		Steam	48.8	1.31		1558		
Textured 80/20 Polyester/Cotton (2.9 oz/yd^2)	75	Air	55.4	1.89	1.5	217	0.145	0.435
		Steam	59.6	1.26		1498		

* Assumes Price of Electricity is 3 Times Cost of Steam